AD NO. _____
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-9043

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

OPEN FIELD SCORING RECORD NO. 426

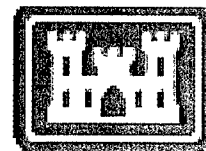SITE LOCATION:
U.S. ARMY YUMA PROVING GROUND

DEMONSTRATOR:
PARSONS
1700 BROADWAY NO. 900
DENVER, CO   80290

TECHNOLOGY TYPE/PLATFORM:
MAGNETOMETER SCHONSTEDT/HAND HELD

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD   21005-5059

JULY 2005

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Environmental Quality
Technology Program

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14. ABSTRACT
This scoring record documents the efforts of Parsons to detect and discriminate inert unexploded ordnance (UXO) utilizing the YPG Standardized UXO Technology Demonstration Site Open Field. Scoring Records have been coordinated by Larry Overbay and the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include, the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

15. SUBJECT TERMS
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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

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characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. Based on configuration of the ground truth at the standardized sites and the defined scoring methodology, there exists the possibility of having anomalies within overlapping halos and/or multiple anomalies within halos. In these cases, the following scoring logic is implemented:

(1) In situations where multiple anomalies exist within a single R_{halo}, the anomaly with the strongest response or highest ranking will be assigned to that particular ground truth item.

(2) For overlapping R_{halo} situations, ordnance has precedence over clutter. The anomaly with the strongest response or highest ranking that is closest to the center of a particular ground truth item gets assigned to that item. Remaining anomalies are retained until all matching is complete.

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(3) Anomalies located within any R_{halo} that do not get associated with a particular ground truth item are thrown out and are not considered in the analysis.

f. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-, 40-, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are inert ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm HEAT Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb

JPG = Jefferson Proving Ground
HEAT = high-explosive antitank

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: William J. Kelso P.E.
   303-764-1932
   william.kelso@parsons.com

Address: Parsons
    1700 Broadway No. 900
    Denver, CO   80290

2.1.2 System Description (provided by demonstrator)

Parsons will locate and flag detectable anomalies at the Standardized Test Sites (except the Active Response Area) using magnetometer (Mag) detection systems. Locations of detected anomalies will be surveyed and results reported on "dig sheets".

Parsons will safely locate and flag detectable magnetic anomalies using hand-held magnetometers (Schonstedt) within the Standardized UXO Technology Demonstration Site at APG, including the Blind Grid (.48 acres), Open Field (13.68 acres), Moguls (1.3 acres), and Wooded (1.35 acres), but not including performance the Active Response Area (3.5 acres). As each anomaly is detected, its location will be marked by a pin flag.

A two-man Survey Crew will next survey the flagged locations of detected anomalies using a Real-Time Kinematic (RTK) Global Positioning System (GPS) instrument. Locations will be recorded in Universal Transverse Mercator (UTM) coordinates on the Standardized UXO Technology Demonstration Site Program Reporting Spreadsheets (Dig Sheets). The Survey Crew will use a Trimble 5700 RTK-GPS survey instrument in the Open Field, Blind Grid, and Moguls; and a Trimble Total Station for the wooded areas where GPS coverage is not available.

Figure 1.   Demonstrator's system, Magnetometer Schonstedt/Hand Held.

2.1.3   Data Processing Description (provided by demonstrator)

The process for detection of anomalies using a magnetometer, marking with pin flags, and surveying by RTK GPS is described as follows. At the outset, lanes will be set up to organize work activities. The lanes will be set up on a 100 x 100 m grid basis and each grid will then be subdivided into lanes that are 1 m wide. The lanes will be marked using ropes stretched between tape measures.   The Ordnance and Explosives (OE) technician will proceed slowly along the lane while scanning with the magnetometer until the technician detects an anomaly. Once the position of the anomaly has been determined, a pin flag will be placed at the location. Once a lane has been completed the team will move to next lane in the grid. Once all the lanes in the grid have been traversed then the team will move on to the next grid.

Once a grid has been completed, then it will become available for surveying.   The surveying team will use either a Trimble 5700 or equivalent RTK GPS system for areas where vegetation doesn't prevent the use of GPS, or a Trimble Total Station in areas of dense vegetation. When using the GPS, the instrument will be placed over each flag and location recorded in a digital data logger. After that, the flag will be removed. In the case of wooded areas, the assistant will place the rod over the flags in the wooded areas and once the operator of the total station indicates that a reading has been acquired, then the assistant will remove the flag and proceed to the next point.

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2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

General. Parsons' QA program consists of an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that the product meets defined standards of quality with a stated level of confidence. Parsons QA/ QC program establishes the methods and procedures that will be used during the project, and is subdivided into two parts as follows:

- Personnel and Operating Procedure QA/QC.

- Instrument/Equipment QA/QC.

Data Quality Objectives. This project is being conducted to establish the baseline standards of performance for the historical standards of industry for Ordnance and Explosives (OE) detection (electromagnetic detection, and magnetic detection). The data quality objective is to emulate as much as possible the historical methods and data quality achieved historically during normal operation of electromagnetic detection of OE.

Personnel and Operating Procedure QA/QC. Field QA/QC will be the responsibility of the Senior Geophysicist for the EM detection and survey activities. Field personnel will be geophysicists and operators with experience in the EM and flag (dig) from the U.S. Navy Kaho'olawe Island site where the EM and flag method was used extensively and found to be the most effective method at detecting buried metallic objects, or other location. Personnel will have received training on the equipment that they are operating.

The operators will be familiarized with site conditions by locating anomalies within the calibration lanes on two occasions. The first time will be without any indication of where the buried items are located. This will ensure that they detect all detectable items present. Once they have successfully performed this task, they will repeat the calibration lanes strip with the actual locations of the buried items marked on the surface. This will allow them to refine their positional marking techniques. Once they have completed these two steps, then the teams can proceed to acquisition over the remainder of the site.

Instrument/Equipment QA/QC: Testing Procedures and Frequency. Instruments and equipment used to locate anomalies and generate survey coordinates will be tested with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications.

Function Test. At least twice daily, all geophysical instruments will be function checked by one of two methods. The operational and test procedures will conform to manufacturer's standard instructions. This field test will ensure that the equipment is functioning within the allowable tolerances.

One method is performed by measuring the instrument response over the daily test grid and comparing that response to its standard response recorded prior to being placed in service. For this EE/CA, USA will establish a test grid, containing no less than two seed items, near the site trailer. Use of equipment that deviates by more than 25 percent from the standard response will be discontinued and the equipment will be repaired or replaced. The second method is performed by placing a small metallic test object on the ground in a standard orientation and centered beneath the equipment sensors. The instrument's response is recorded and compared to its initial response measured over the same object prior to being placed in service. For this project, trailer ball hitches will be used as the test objects. If the response in the field is greater than 20-percent of the initial response, the instrument will be repaired or removed from service.

Preventive Maintenance. Equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced prior in accordance with the manufacturer's specified recommendations. Any anomalies in the instrumentation that affect the survey will be noted and the instrument replaced by the vendor. No other maintenance procedures will be used, other than charging the batteries and ensuring that the connectors stay dry.

Survey Data Quality Control:

Data Acquisition. Parsons' Quality Control program ensures the precision and accuracy of analyses by detecting errors and preventing recurrences or measuring the degree of error inherent in the activities and procedures. Any raw data from survey measurements will be appropriately recorded and notated in the field notebooks or Data Loggers.

Quality control will be conducted for all hardcopy (Dig Sheets) and electronic deliverables. At a minimum the following measures will be conducted:

- Standard coordinate systems (UTM) will be used and verified throughout the project.

- All deliverables will be peer reviewed to ensure accuracy.

- Electronic data will be backed up periodically.

Corrective Action. The following procedures have been established to assure that conditions adverse to quality such as malfunctions, deficiencies, deviations, and errors are promptly investigated, documented, evaluated, and corrected.

When a significant condition adverse to quality is noted in the field, the cause of the condition will be determined and corrective action taken to preclude repetition. Condition identification, cause, reference documents, and corrective action planned will be documented and reported to the Site Geophysicist. Implementation of corrective actions will be verified by

documented follow-up action. All project personnel have the daily responsibility to promptly identify problem areas, solicit approved corrective actions, and report any condition adverse to quality.

Corrective actions will be initiated at a minimum:

- When predetermined acceptance standards are not attained.

- When procedures or data compiled are determined to be faulty.

- When equipment or instrumentation is found faulty.

- When quality assurance requirements are violated.

- As a result of system and performance audits.

- As a result of management assessment.

Field Investigation Recordkeeping:

Daily Field Activity Records. Field activity logbooks will be maintained daily, if applicable, and all entries will be recorded in ink. All personnel will use bound and numbered field logbooks with consecutively numbered pages. The following logs will be maintained.

Daily Activity Log:

- Date and recorder of field information.

- Start and end time of work activities including breaks, lunch, and down times.

- Visitors.

- Weather conditions.

- Relevant events.

- Important phone calls.

- Changes from approved or planned work instructions; and

- Signature of the on-site QA/QC Manager.

Safety Log:

- Date and recorder of log,

- Tailgate safety briefing (time conducted and by whom),

- Weather conditions,

- Significant site events relating to safety,

- Accidents, and

- Stop work due to safety,

Demonstrator's Field Personnel.

Six personnel total will be used as follows:

- Two geophysical crews each consisting of one Geophysicist and one Geophysics assistant.

- One Survey crew consisting of one Lead Surveyor and one Surveyor Assistant.

Support Equipment Required. Temporary storage space is required for overnight storage of instruments and equipment during the work.

Frequency and Radio Utilization. The Trimble GPS RTK system utilizes radio communication to transmit information from the GPS base station to the rover units. The radio can utilize a range of frequencies of .25 MHz in one of three bandwidths (410-420 MHz, 430-450 MH, or 450-470 MHz. This portion of the frequency spectrum is commonly used for accurate GPS positioning in geophysical surveying. One of the frequencies that has minimal interference from other sources will be selected and will transmit a data pulse every 1 s for a majority of the work day. The radio, which is only capable of data transmission from the GPS base station (no voice transmission), has a selectable power output of 2, 10 or 25 W. The radio licenses are held by the vendor that will supply the equipment to Parsons.

2.1.6 **Additional Records**

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org. The Blind Grid counterpart to this report is Scoring Record No. 606.

2.2 YPG SITE INFORMATION

2.2.1 Location

YPG is located adjacent to the Colorado River in the Sonoran Desert. The UXO Standardized Test Site is located south of Pole Line Road and east of the Countermine Testing and Training Range. The Open Field range, Calibration Grid, Blind Grid, Mogul area, and Desert Extreme area comprise the 350 by 500-meter general test site area. The open field site is the largest of the test sites and measures approximately 200 by 350 meters. To the east of the open field range are the calibration and blind test grids that measure 30 by 40 meters and 40 by 40 meters, respectively. South of the Open Field is the 135- by 80-meter Mogul area consisting of a sequence of man-made depressions. The Desert Extreme area is located southeast of the open field site and has dimensions of 50 by 100 meters. The Desert Extreme area, covered with desert-type vegetation, is used to test the performance of different sensor platforms in a more severe desert conditions/environment.

2.2.2 Soil Type

Soil samples were collected at the YPG UXO Standardized Test Site by ERDC to characterize the shallow subsurface (< 3 m). Both surface grab samples and continuous soil borings were acquired. The soils were subjected to several laboratory analyses, including sieve/hydrometer, water content, magnetic susceptibility, dielectric permittivity, X-ray diffraction, and visual description.

There are two soil complexes present within the site, Riverbend-Carrizo and Cristobal-Gunsight. The Riverbend-Carrizo complex is comprised of mixed stream alluvium, whereas the Cristobal-Gunsight complex is derived from fan alluvium. The Cristobal-Gunsight complex covers the majority of the site. Most of the soil samples were classified as either a sandy loam or loamy sand, with most samples containing gravel-size particles. All samples had a measured water content less than 7 percent, except for two that contained 11-percent moisture. The majority of soil samples had water content between 1 to 2 percent. Samples containing more than 3 percent were generally deeper than 1 meter.

An X-ray diffraction analysis on four soil samples indicated a basic mineralogy of quartz, calcite, mica, feldspar, magnetite, and some clay. The presence of magnetite imparted a moderate magnetic susceptibility, with volume susceptibilities generally greater than 100 by 10-5 SI.

For more details concerning the soil properties at the YPG test site, go to www.uxotestsites.org on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at YPG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains the 15 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind Grid	Contains 400 grid cells in a 0.16-hectare (0.39-acre) site. The center of each grid cell contains ordnance, clutter, or nothing.
Open Field	A 4-hectare (10-acre) site containing open areas, dips, ruts, and obstructions, including vegetation.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (12 through 15 and 18 October 2004)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	0.33
Open Field	39.00

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

A YPG weather station located approximately one mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2004	Average Temperature, °C	Total Daily Precipitation, in.
October 12	26.7	0.00
October 13	26.6	0.00
October 14	30.4	0.00
October 15	27.1	0.00
October 18	23.6	0.00

3.3.2 Field Conditions

The field was dry and the weather was warm throughout the Parson survey.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: Blind Grid, Calibration, Desert Extreme, and Mogul areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

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3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. A six-person crew took 30 minutes to perform the initial setup and mobilization. There was 5 hours and 53 minutes of daily equipment preparation and end of the day equipment break down lasted 50 minutes.

3.4.2 Calibration

Parsons spent a total of 20 minutes in the calibration lanes, all of which was spent collecting data.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total Site Survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for no site usage time. These activities included changing out batteries and routine data checks to ensure the data was being properly recorded/collected. Parsons spent an additional 5 hours and 15 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying the Open Field.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

Parsons spent a total time of 39 hours in the Open Field area, 27 hours and 2 minutes of which was spent collecting data.

3.4.5 Demobilization

The Parsons survey crew went on to conducted a full demonstration of the site. Therefore, demobilization did not occur until 21 October 2004. On that day, it took the crew 50 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

Parsons submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Ben McCallister
Bart Hoestra
Eric Tennyson
4 additional site survey personnel

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

Parsons set up grids in the open field and surveyed them individually until completion in a east to west direction.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

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SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

(Not applicable to this technology)

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

(Not applicable to this technology)

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented in Tables 5a and 5b (for cost results, see section 5). Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range (see app A for size definitions). The results are relative to the number of ordnances emplaced. Depth is measured from the geometric center of anomalies.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Tables 5a and 5b have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the summary presented in Table 5a exhibits results based on the subset of the ground truth that is solely the ferrous anomalies. Table 5b exhibits results based on the full ground truth. All other tables presented in this section are based on scoring against the ferrous only ground truth. The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

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TABLE 5a. SUMMARY OF OPEN FIELD RESULTS (FERROUS ONLY)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.60	0.55	0.65	0.50	0.65	0.75	0.65	0.65	0.25
P_d Low 90% Conf	0.57	0.50	0.62	0.46	0.58	0.69	0.59	0.60	0.16
P_d Upper 90% Conf	0.63	0.59	0.71	0.56	0.69	0.81	0.67	0.71	0.36
P_{fp}	0.65	-	-	-	-	-	0.70	0.60	0.00
P_{fp} Low 90% Conf	0.66	-	-	-	-	-	0.68	0.59	0.00
P_{fp} Upper 90% Conf	0.69	-	-	-	-	-	0.72	0.65	0.21
BAR	0.50	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Low 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Upper 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_{fp}	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Low 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Upper 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
BAR	N/A	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.00
Recommended Discrimination Stage Threshold: 0.00

TABLE 5b. SUMMARY OF OPEN FIELD RESULTS (FULL GROUND TRUTH)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.55	0.45	0.65	0.40	0.65	0.75	0.55	0.60	0.25
P_d Low 90% Conf	0.50	0.41	0.60	0.37	0.58	0.69	0.51	0.53	0.16
P_d Upper 90% Conf	0.56	0.49	0.69	0.45	0.69	0.81	0.58	0.64	0.35
P_{fp}	0.65	-	-	-	-	-	0.70	0.60	0.00
P_{fp} Low 90% Conf	0.65	-	-	-	-	-	0.68	0.58	0.00
P_{fp} Upper 90% Conf	0.69	-	-	-	-	-	0.72	0.65	0.21
BAR	0.50	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Low 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Upper 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_{fp}	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Low 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Upper 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
BAR	N/A	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.00
Recommended Discrimination Stage Threshold 0.00

Note: The recommended discrimination stage threshold values are provided by the demonstrator.
No discrimination algorithm was applied. Therefore, the discrimination
stage results are not applicable.

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4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Due to technical limitations of the system used for this demonstration, no attempt was made to discriminate. Therefore, the following tables presented in this section are not applicable.

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	N/A	N/A	N/A
With No Loss of P_d	N/A	N/A	N/A

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 7). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	N/A
Medium	N/A
Large	N/A
Overall	N/A

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (X, Y) positions are known to be the centers of each grid square.

**TABLE 8.   MEAN LOCATION ERROR AND
STANDARD DEVIATION (M)**

	Mean	Standard Deviation
Northing	-0.03	0.15
Easting	0.00	0.18
Depth	N/A	N/A

Note: Demonstrator did not attempt to declare depth of detection.

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 9. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial Setup				
Supervisor	1	$95.00	0.50	$47.50
Data Analyst	1	57.00	0.50	28.50
Field Support	4	28.50	0.50	57.00
SubTotal				**$133.00**
Calibration				
Supervisor	1	$95.00	0.33	$31.35
Data Analyst	1	57.00	0.33	18.81
Field Support	4	28.50	0.33	37.62
SubTotal				**$87.78**
Site Survey				
Supervisor	1	$95.00	39.00	$3,705.00
Data Analyst	1	57.00	39.00	2,223.00
Field Support	4	28.50	39.00	4,446.00
SubTotal				**$10,374.00**

See notes at end of table.

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TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	0.83	$78.85
Data Analyst	1	57.00	0.83	47.31
Field Support	5	28.50	0.83	118.28
Subtotal				**$244.44**
Total				**$10,839.22**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO BLIND GRID DEMONSTRATION (BASED ON FERROUS ONLY GROUND TRUTH)

6.1 SUMMARY OF RESULTS FROM BLIND GRID DEMONSTRATION

Table 10 shows the results from the Blind Grid survey conducted prior to surveying the Open Field during the same site visit in October of 2004. Due to the system utilizing magnetometer type sensors, all results presented in the following section have been based on performance scoring against the ferrous only ground truth anomalies. For more details on the Blind Grid survey results reference section 2.1.6.

TABLE 10. SUMMARY OF BLIND GRID RESULTS FOR THE MAG SCHONSTEDT (FERROUS ONLY)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.80	0.75	0.90	0.80	0.85	0.80	0.80	0.85	0.70
P_d Low 90% Conf	0.72	0.62	0.77	0.65	0.68	0.58	0.66	0.72	0.40
P_d Upper 90% Conf	0.86	0.83	0.96	0.88	0.92	0.92	0.87	0.95	0.92
P_{fp}	0.90	-	-	-	-	-	0.90	0.80	0.00
P_{fp} Low 90% Conf	0.84	-	-	-	-	-	0.87	0.65	-
P_{fp} Upper 90% Conf	0.92	-	-	-	-	-	0.95	0.88	-
P_{ba}	0.85	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Low 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Upper 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_{fp}	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Low 90% Conf	N/A	-	-	-	-	-	N/A	N/A	-
P_{fp} Upper 90% Conf	N/A	-	-	-	-	-	N/A	N/A	-
P_{ba}	N/A	-	-	-	-	-	-	-	-

6.2 COMPARISON OF ROC CURVES USING ALL ORDNANCE CATEGORIES

(Not applicable for this technology)

6.3 COMPARISON OF ROC CURVES USING ORDNANCE LARGER THAN 20 MM

(Not applicable for this technology)

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6.4 STATISTICAL COMPARISONS

Statistical Chi-square significance tests were used to compare results between the Blind Grid and Open Field scenarios. The intent of the comparison is to determine if the feature introduced in each scenario has a degrading effect on the performance of the sensor system. However, any modifications in the UXO sensor system during the test, like changes in the processing or changes in the selection of the operating threshold, will also contribute to performance differences.

The Chi-square test for comparison between ratios was used at a significance level of 0.05 to compare Blind Grid to Open Field with regard to P_d^{res}, P_d^{disc}, P_{fp}^{res} and P_{fp}^{disc}, Efficiency and Rejection Rate. These results are presented in Table 11. A detailed explanation and example of the Chi-square application is located in Appendix A.

TABLE 11. CHI-SQUARE RESULTS - BLIND GRID VERSUS OPEN FIELD

Metric	Small	Medium	Large	Overall
P_d^{res}	Significant	Not Significant	Not Significant	Significant
P_d^{disc}	N/A	N/A	N/A	N/A
P_{fp}^{res}	Not Significant	Not Significant	Not Significant	Not Significant
P_{fp}^{disc}	-	-	-	N/A
Efficiency	-	-	-	N/A
Rejection rate	-	-	-	N/A

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SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-pound bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/ (No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to nonordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.
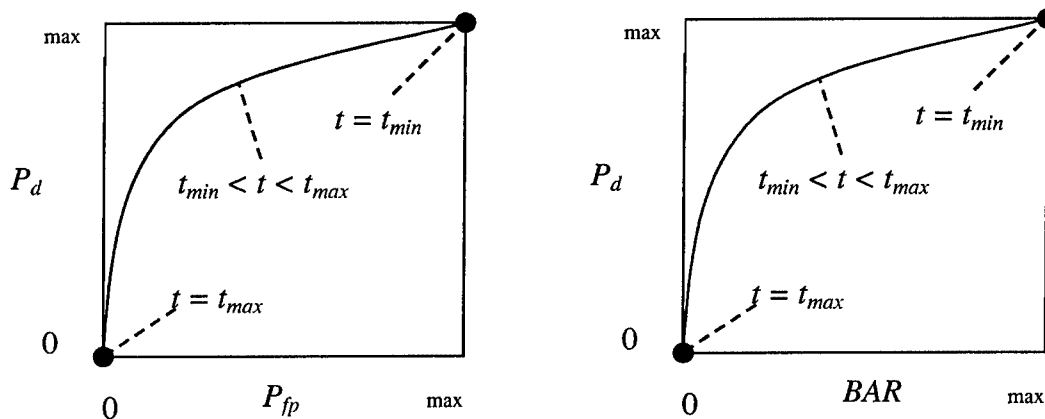
Figure A-1. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

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[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

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METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 3).

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X's system is significantly degraded by the more challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the

Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind Grid	Open Field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

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P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field-testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

12 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	15.7	0.00
08:00	20.9	0.00
09:00	23.0	0.00
10:00	25.1	0.00
11:00	26.0	0.00
12:00	28.6	0.00
13:00	30.2	0.00
14:00	30.6	0.00
15:00	31.0	0.00
16:00	31.8	0.00
17:00	30.6	0.00

13 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	15.8	0.00
08:00	18.8	0.00
09:00	22.3	0.00
10:00	23.5	0.00
11:00	26.0	0.00
12:00	28.5	0.00
13:00	29.9	0.00
14:00	30.4	0.00
15:00	33.0	0.00
16:00	33.4	0.00
17:00	31.4	0.00

14 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	23.1	0.00
08:00	25.3	0.00
09:00	28.4	0.00
10:00	29.9	0.00
11:00	30.9	0.00
12:00	31.8	0.00
13:00	32.4	0.00
14:00	32.8	0.00
15:00	33.4	0.00
16:00	33.4	0.00
17:00	33.3	0.00

15 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	16.2	0.00
08:00	16.4	0.00
09:00	22.5	0.00
10:00	25.6	0.00
11:00	27.7	0.00
12:00	30.5	0.00
13:00	31.5	0.00
14:00	32.1	0.00
15:00	32.5	0.00
16:00	31.9	0.00
17:00	31.1	0.00

18 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	17.7	0.00
08:00	18.4	0.00
09:00	21.0	0.00
10:00	22.9	0.00
11:00	24.3	0.00
12:00	25.4	0.00
13:00	25.7	0.00
14:00	26.2	0.00
15:00	26.2	0.00
16:00	26.2	0.00
17:00	25.9	0.00

19 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	15.5	0.00
08:00	18.0	0.00
09:00	20.6	0.00
10:00	21.8	0.00
11:00	24.2	0.00
12:00	24.6	0.00
13:00	25.6	0.00
14:00	25.3	0.00
15:00	26.2	0.00
16:00	26.1	0.00
17:00	25.2	0.00

20 October 2004		
Time	Temperature °C	Precipitation (in.)
07:00	18.2	0.00
08:00	19.8	0.00
09:00	22.4	0.00
10:00	23.6	0.00
11:00	25.0	0.00
12:00	25.5	0.00
13:00	26.3	0.00
14:00	26.5	0.00
15:00	25.8	0.00
16:00	25.5	0.00
17:00	23.9	0.00

APPENDIX C. SOIL MOISTURE

Demonstrator: Parsons - Mag and Flag

Date: October 12, 2004
Times: 0800 hours, 1300 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.5	1.8
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.0
	12 to 24	3.8	3.8
	24 to 36	4.0	4.0
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.0
	12 to 24	3.3	3.3
	24 to 36	3.7	3.7
	36 to 48	3.9	3.9

Date: October 13, 2004
Times: 0640 hours, 1330 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.6	1.6
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.7	1.7
	6 to 12	2.0	2.0
	12 to 24	3.7	3.7
	24 to 36	3.9	3.9
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.0
	12 to 24	3.4	3.4
	24 to 36	3.9	3.9
	36 to 48	4.1	4.1

Date: October 14, 2004
Times: 0700 hours, 1230 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.6	1.6
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.7	1.7
	6 to 12	2.0	2.0
	12 to 24	3.6	3.6
	24 to 36	3.9	3.9
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.0
	12 to 24	3.4	3.4
	24 to 36	3.9	3.9
	36 to 48	4.1	4.1

Date: October 15, 2004
Times: 0630 hours, 1130 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.6	1.6
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.7	1.7
	6 to 12	2.0	2.0
	12 to 24	3.6	3.6
	24 to 36	3.9	3.9
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.0
	12 to 24	3.4	3.4
	24 to 36	3.9	3.9
	36 to 48	4.1	4.1

Date: October 18, 2004
Times: 0700 hours, 1300 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.9	1.6
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.7	1.6
	6 to 12	2.0	2.1
	12 to 24	3.6	3.4
	24 to 36	3.9	3.9
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.7	1.6
	6 to 12	2.0	2.3
	12 to 24	3.4	3.2
	24 to 36	3.9	3.9
	36 to 48	4.1	4.0

Date: October 19, 2004
Times: 0630 hours, 1300 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.8	1.8
	6 to 12	2.2	2.2
	12 to 24	3.7	3.7
	24 to 36	3.6	3.6
	36 to 48	4.1	4.1
Mogul Area	0 to 6	1.6	1.6
	6 to 12	2.0	2.1
	12 to 24	3.6	3.4
	24 to 36	3.9	4.0
	36 to 48	4.0	4.0
Desert Extreme Area	0 to 6	1.7	1.6
	6 to 12	2.0	1.8
	12 to 24	3.4	3.2
	24 to 36	3.9	3.9
	36 to 48	1.8	1.8

Date: October 20, 2004
Times: 0630 hours, 1300 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Calibration Area	0 to 6	1.8	NA
	6 to 12	2.2	NA
	12 to 24	3.7	NA
	24 to 36	3.6	NA
	36 to 48	4.1	NA
Mogul Area	0 to 6	1.6	NA
	6 to 12	2.0	NA
	12 to 24	3.4	NA
	24 to 36	3.9	NA
	36 to 48	4.0	NA
Desert Extreme Area	0 to 6	1.7	NA
	6 to 12	2.0	NA
	12 to 24	3.4	NA
	24 to 36	3.9	NA
	36 to 48	4.1	NA

MAG & FLAG

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/12/2004	6	CALIBRATION LANES	0730	0800	30	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION	NA	NA	NA	SUNNY WARM
10/12/2004	6	CALIBRATION LANES	0800	0820	20	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH TOTAL 344 HITS	NA	NA	LINEAR	SUNNY WARM
10/12/2004	6	BLIND TEST GRID	0820	0905	45	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH	NA	NA	LINEAR	SUNNY WARM
10/12/2004	6	OPEN FIELD	0905	0940	35	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID A5	NA	NA	NA	SUNNY HOT
10/12/2004	6	OPEN FIELD	0940	1125	105	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID A5	GPS	CHIPS	LINEAR	SUNNY HOT
10/12/2004	6	OPEN FIELD	1125	1230	65	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY HOT
10/12/2004	6	OPEN FIELD	1230	1240	10	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID A5	GPS	CHIPS	LINEAR	SUNNY HOT
10/12/2004	6	OPEN FIELD	1240	1253	13	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID B5	NA	NA	NA	SUNNY HOT
10/12/2004	6	OPEN FIELD	1253	1409	76	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID B5	GPS	CHIPS	LINEAR	SUNNY HOT
10/12/2004	6	OPEN FIELD	1409	1417	8	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID C5	NA	NA	NA	SUNNY HOT

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
						MAG & FLAG						
10/12/2004	6	OPEN FIELD	1417	1520	63	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C5	GPS	CHIPS	LINEAR	SUNNY	HOT
10/12/2004	6	OPEN FIELD	1520	1530	10	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	HOT
10/13/2004	6	OPEN FIELD	0640	0655	15	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION	NA	NA	NA	SUNNY	COOL
10/13/2004	7	OPEN FIELD	0655	0725	30	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C5	GPS	CHIPS	LINEAR	SUNNY	COOL
10/13/2004	7	OPEN FIELD	0725	0855	90	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID D5	GPS	CHIPS	LINEAR	SUNNY	WARM
10/13/2004	7	OPEN FIELD	0855	0900	5	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	0900	0910	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID E5	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	0910	1015	65	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID E5	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1015	1025	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID F5	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1025	1045	20	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID F5	GPS	CHIPS	LINEAR	SUNNY	HOT

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
						MAG & FLAG						
10/13/2004	7	OPEN FIELD	1045	1055	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID G4	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1055	1130	35	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID G4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1130	1220	50	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1220	1230	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID F4	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1230	1329	59	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID F4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1329	1334	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID E4	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1334	1405	31	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID E4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1405	1425	20	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1425	1455	30	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID E4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1455	1505	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID D4	NA	NA	NA	SUNNY	HOT

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
						MAG & FLAG						
10/13/2004	7	OPEN FIELD	1505	1555	50	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID D4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1555	1605	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID C4	NA	NA	NA	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1605	1615	10	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C4	GPS	CHIPS	LINEAR	SUNNY	HOT
10/13/2004	7	OPEN FIELD	1615	1630	15	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	HOT
10/14/2004	7	OPEN FIELD	0630	0705	35	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID C4	NA	NA	NA	SUNNY	WARM
10/14/2004	7	OPEN FIELD	0705	0755	50	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C4	GPS	CHIPS	LINEAR	SUNNY	WARM
10/14/2004	7	OPEN FIELD	0755	0805	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID B4	NA	NA	NA	SUNNY	WARM
10/14/2004	7	OPEN FIELD	0805	0905	65	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID B4	GPS	CHIPS	LINEAR	SUNNY	WARM
10/14/2004	7	OPEN FIELD	0905	0920	15	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	WARM

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
MAG & FLAG												
10/14/2004	7	OPEN FIELD	0915	0935	20	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID A4	NA	NA	NA	SUNNY	WARM WINDY
10/14/2004	7	OPEN FIELD	0935	1050	75	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID A4	GPS	CHIPS	LINEAR	SUNNY	HOT WINDY
10/14/2004	7	OPEN FIELD	1050	1115	25	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID A3	NA	NA	NA	SUNNY	HOT WINDY
10/14/2004	7	OPEN FIELD	1115	1145	30	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY	HOT
10/14/2004	7	OPEN FIELD	1145	1245	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID A3	GPS	CHIPS	LINEAR	SUNNY	HOT
10/14/2004	7	OPEN FIELD	1245	1255	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID B3	NA	NA	NA	SUNNY	HOT
10/14/2004	7	OPEN FIELD	1255	1355	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID B3	GPS	CHIPS	LINEAR	SUNNY	HOT
10/14/2004	7	OPEN FIELD	1355	1410	15	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID C3	NA	NA	NA	SUNNY	HOT
10/14/2004	7	OPEN FIELD	1410	1430	20	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	HOT
10/15/2004	7	OPEN FIELD	0630	0645	15	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION	NA	NA	NA	SUNNY	COOL

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

MAG & FLAG

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
10/15/2004	7	OPEN FIELD	0645	0740	55	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C3	GPS	CHIPS	LINEAR	SUNNY	COOL
10/15/2004	7	OPEN FIELD	0740	0745	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID D3	NA	NA	NA	SUNNY	COOL
10/15/2004	7	OPEN FIELD	0745	0845	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID D3	GPS	CHIPS	LINEAR	SUNNY	COOL
10/15/2004	7	OPEN FIELD	0845	0900	15	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	WARM
10/15/2004	7	OPEN FIELD	0900	0925	25	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID E3	NA	NA	NA	SUNNY	WARM
10/15/2004	7	OPEN FIELD	0925	1020	55	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID E3	GPS	CHIPS	LINEAR	SUNNY	WARM
10/15/2004	7	OPEN FIELD	1020	1027	7	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID F3	NA	NA	NA	SUNNY	WARM
10/15/2004	7	OPEN FIELD	1027	1105	38	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID F3	GPS	CHIPS	LINEAR	SUNNY	HOT
10/15/2004	7	OPEN FIELD	1105	1145	40	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY	HOT
10/15/2004	7	OPEN FIELD	1145	1220	35	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID F3	GPS	CHIPS	LINEAR	SUNNY	HOT

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status MAG & FLAG	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
10/15/2004	7	OPEN FIELD	1220	1225	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID G3	NA	NA	NA	SUNNY	HOT
10/15/2004	7	OPEN FIELD	1225	1310	45	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID G3	GPS	CHIPS	LINEAR	SUNNY	HOT
10/15/2004	7	OPEN FIELD	1310	1325	15	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID G2	NA	NA	NA	SUNNY	HOT
10/15/2004	7	OPEN FIELD	1325	1330	5	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	HOT
10/18/2004	7	OPEN FIELD	0640	0705	25	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID G2	NA	NA	NA	SUNNY	COOL
10/18/2004	7	OPEN FIELD	0705	0800	55	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID G2	GPS	CHIPS	LINEAR	SUNNY	COOL
10/18/2004	7	OPEN FIELD	0800	0805	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID F2	NA	NA	NA	SUNNY	COOL
10/18/2004	7	OPEN FIELD	0805	0905	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID F2	GPS	CHIPS	LINEAR	SUNNY	COOL
10/18/2004	7	OPEN FIELD	0905	0920	15	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	WARM

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

MAG & FLAG

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/18/2004	7	OPEN FIELD	0920	0930	10	COLLECT DATA	SETUP/MOBILIZATION SET UP TEST AREA GRID E2	NA	NA	NA	SUNNY WARM
10/18/2004	7	OPEN FIELD	0930	1015	45	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID E2	GPS	CHIPS	LINEAR	SUNNY WARM
10/18/2004	7	OPEN FIELD	1015	1020	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID D2	NA	NA	NA	SUNNY WARM
10/18/2004	7	OPEN FIELD	1020	1120	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID D2	GPS	CHIPS	LINEAR	SUNNY WARM
10/18/2004	7	OPEN FIELD	1120	1210	50	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY WARM
10/18/2004	7	OPEN FIELD	1210	1250	40	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID C2	GPS	CHIPS	LINEAR	SUNNY WARM
10/18/2004	7	OPEN FIELD	1250	1255	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRIDB2	NA	NA	NA	SUNNY WARM WINDY
10/18/2004	7	OPEN FIELD	1255	1335	40	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID B2	GPS	CHIPS	LINEAR	SUNNY WARM WINDY
10/18/2004	7	OPEN FIELD	1335	1345	10	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY WARM WINDY
10/18/2004	7	OPEN FIELD	1345	1355	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID A2	NA	NA	NA	SUNNY WARM WINDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
10/18/2004	7	OPEN FIELD	1355	1440	45	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRID A2	GPS	CHIPS TOTAL 3858 HITS	LINEAR	SUNNY	WARM WINDY
10/18/2004	7	MOGUL	1440	1500	20	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA MOGUL	NA	NA	NA	SUNNY	WARM WINDY
10/18/2004	7	MOGUL	1500	1520	20	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA			SUNNY	WARM WINDY
10/19/2004	7	MOGUL	0635	0715	40	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA MOGUL	NA	NA	NA	SUNNY	COOL
10/19/2004	7	MOGUL	0715	0825	70	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRIDS H1/H2/H3	GPS	CHIPS	LINEAR	SUNNY	COOL
10/19/2004	7	MOGUL	0825	0830	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRIDS I1/I2/I3	NA	NA	NA	SUNNY	COOL
10/19/2004	7	MOGUL	0830	0910	30	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRIDS I1/I2/I3	GPS	CHIPS	LINEAR	SUNNY	COOL
10/19/2004	7	MOGUL	0910	0930	20	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY	WARM
10/19/2004	7	MOGUL	0930	1000	30	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRIDS I1/I2/I3	GPS	CHIPS	LINEAR	SUNNY	WARM

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/19/2004	7	MOGUL	1000	1010	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRIDS I1/I2/I3	NA	NA	NA	SUNNY WARM
10/19/2004	7	MOGUL	1010	1110	60	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRIDS I1/I2/I3	GPS	CHIPS	LINEAR	SUNNY WARM
10/19/2004	7	MOGUL	1110	1150	40	BREAK/LUNCH	LUNCH	NA	NA	NA	SUNNY WARM
10/19/2004	7	MOGUL	1150	1200	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRIDS J1/J2/J3	NA	NA	NA	SUNNY WARM
10/19/2004	7	MOGUL	1200	1310	70	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL EAST TO WEST GRIDS J1/J2/J3	GPS	CHIPS TOTAL MOGUL 674 HITS	LINEAR	SUNNY WARM
10/19/2004	7	MOGUL	1310	1325	15	BREAK/LUNCH	BREAK	NA	NA	NA	SUNNY HOT WINDY
10/19/2004	7	YUMA EXTREME	1325	1340	15	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA YUMA EXTREME GRID G7	NA	NA	NA	SUNNY HOT WINDY
10/19/2004	7	YUMA EXTREME	1340	1445	65	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH GRID G7	GPS	CHIPS	LINEAR	SUNNY HOT WINDY
10/19/2004	7	YUMA EXTREME	1445	1515	30	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY HOT WINDY

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Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
10/19/2004	7	YUMA EXTREME	1515	1523	8	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	HOT WINDY
10/20/2004	7	YUMA EXTREME	0635	0700	25	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID H7	NA	NA	NA	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0700	0740	40	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH GRID H7	GPS	CHIPS	LINEAR	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0740	0750	10	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID H8	NA	NA	NA	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0750	0840	50	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH GRID H8	GPS	CHIPS	LINEAR	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0840	0845	5	SETUP/DAILY START/ STOP/CALIBRATION	SETUP/MOBILIZATION SET UP TEST AREA GRID G8	NA	NA	NA	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0845	0935	50	COLLECT DATA	COLLECTED DATA BI-DIRECTIONAL NORTH TO SOUTH GRID G8	GPS	CHIPS TOTAL 454 HITS	LINEAR	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	0935	0945	10	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	COOL

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
						MAG & FLAG						
10/20/2004	7	YUMA EXTREME	0945	1030	45	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHECK DATA	NA	NA	NA	SUNNY	COOL
10/20/2004	7	YUMA EXTREME	1030	1040	10	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	COOL
10/21/2004	7	YUMA EXTREME	0710	0800	50	DEMOBILIZATION	DEMOBILIZATION END OF TEST TURN-IN DATA	NA	NA	NA	CLOUDY	RAIN

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

5. Practical Nonparametric Statistics, W.J. Conover, John Wiley & Sons, 1980, pages 144 through 151.

APPENDIX F. ABBREVIATIONS

AEC   = U.S. Army Environmental Center
APG   = Aberdeen Proving Ground
ASCII = American Standard Code for Information Interchange.
ATC   = U.S. Army Aberdeen Test Center
EM   = electromagnetic
EMI   = electromagnetic interference
EMIS   = Electromagnetic Induction Spectroscopy
ERDC   = U.S. Army Corps of Engineers Engineering Research and Development Center
ESTCP = Environmental Security Technology Certification Program
EQT   = Army Environmental Quality Technology Program
GPS   = Global Positioning System
JPG   = Jefferson Proving Ground
OE   = Ordnance and Explosives
POC   = point of contact
QA   = quality assurance
QC   = quality control
ROC   = receiver-operating characteristic
RTK   = real time kinematic
RTS   = Robotic Total Station
SERDP = Strategic Environmental Research and Development Program
UXO   = unexploded ordnance
YPG   = U.S. Army Yuma Proving Ground

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